



United State Environmental Protection Agency

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December 2009

**An assessment of the  
EPA Preliminary Remediation Goal Calculators  
for their practical application to OEM operations and  
long-term recovery following an RDD / IND terrorist attack**

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CONTRACT NO.: EP-W-06-089  
Decontamination Analytical and Technical Service (DATS) Contract  
TDD NO.: TO 01-09-03-0034

## **Disclaimer**

This report is meant to be a summary of information for OEM Senior Management. Mention of alternative clean-up guidance tools, other than those where the agency has officially documented concurrence (e.g., Department of Homeland Security RDD/IND Guidance Document) should not be viewed as an endorsement of the approach. Similarly, exclusion of any alternative clean-up guidance tools should not be viewed as not being endorsed by USEPA; it merely means that the information was not reviewed as part of this activity. Also, the data presented were derived from sources in the reference literature, EPA documents and websites. Areas that discuss the potential impact to EPA operations may be somewhat subjective as they rely on future predictions and based on the professional judgment of the authors. In addition, all figures were developed by the authors or adapted from the scientific literature for informational use in this document.

## **Preface**

This report was written to help EPA OEM senior management determine if the PRG calculators, which were developed specifically for the Superfund remedial program, are viable tools to be used for the long-term recovery operations following a radioactive dispersal device (RDD) or improvised nuclear device (IND) terrorist attack. This effort should not be viewed as a comprehensive scientific review of the technical accuracy of the PRG calculators, although any issues observed while conducting this work are included. If you have any comments on the document please contact:

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## ACRONYMS AND ABBREVIATIONS

ALARA	As low as reasonably achievable
ANL	Argonne National Laboratory
ANSI	American National Standards Institute
ARAR	Applicable or Relevant and Appropriate Requirements
Ba	Barium
BNL	Brookhaven National Laboratory
BPRG	Preliminary Remediation Goals for Radionuclides in Buildings
CAA	Clean Air Act
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
cm <sup>2</sup>	Square centimeter
Co	Cobalt
COC	Contaminant of concern
COE	U.S. Army Corps of Engineers
Cs	Cesium
DHS	Department of Homeland Security
DOE	U.S. Department of Energy
dpm	Disintegration per minute
EPA	U.S. Environmental Protection Agency
HPS	Health Physics Society
ICRP	International Council on Radiation Protection and Measurements
IND	Improvised nuclear device
INEEL	Idaho National Engineering and Environmental Laboratory
Ir	Iridium
MDA	Minimum detectable activity
mrem	Millirem
NASA	National Aeronautics and Space Administration
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NCRP	National Council on Radiation Protection and Measurements
NRC	Nuclear Regulatory Commission
OMB	Office of Management and Budget
OEM	Office of Emergency Management
OSRTI	Office of Superfund Remediation and Technology Innovation
OSWER	Office of Solid Waste and Emergency Response
PAG	Protective Action Guideline
pCi/g	Picocurie per gram
Po	Polonium
PRG	Preliminary remediation goal
Ra	Radium
RCRA	Resource Conservation and Recovery Act
RDD	Radiological dispersal device
ROD	Record of Decision
SDCC	Dose Compliance Concentrations for Radionuclides in Outdoor Surfaces
SDWA	Safe Drinking Water Act
SHEMP	Safety Health and Environmental Management Program

SI	International System of Units
SPRG	Preliminary Remediation Goals for Radionuclides on Outside Surfaces
Sr	Strontium
SRS	Savannah River Site
Th	Thorium
U	Uranium
Y	Yttrium

# EXECUTIVE SUMMARY

Two calculator tools developed by the U.S. EPA Office of Superfund Remediation and Technology Innovation were assessed to determine if they could be practically applied during an emergency response and long-term recovery following a terrorist attack involving a radiological dispersal device (RDD) or improvised nuclear device (IND). The two calculators, Preliminary Remediation Goals for Radionuclides in Outside Surfaces (SPRG) and the Preliminary Remediation Goals for Radionuclides in Buildings (BPRG), were developed for use in the remediation of contaminated sites governed by Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) regulations. This assessment was not a comprehensive review of the scientific or technical integrity of these calculators; however, some issues were identified in the context of applying these calculators to real-world applications likely to be encountered during OEM responses.

A summary of alternative benchmarks that have been used throughout the nuclear industry for clearing contaminated items and facilities is provided. Additionally, a list of previous EPA superfund cleanup sites contaminated with radioactive materials is presented. The authors briefly discuss the lessons learned from another real-world incident - the UK Po-210 poisoning of Alexander Litvinenko and subsequent cleanup, how the PRG calculators could apply to these incidents, and how the risk management approach of using the PRGs could potentially impact the agency from a political, economic, and social perspective.

Several issues were identified with the PRG calculators relative to their practical application to RDD/IND long-term recovery operations.

1. SPRG values were not internally consistent between the download tables and the electronic calculator.
2. SPRG values exceeded the EPA SHEMP Manual radiation turnback values for ground contamination levels.
3. SPRG provided values that are not detectable by laboratory or field instrumentation.
4. SPRG and BPRG provided values in units not consistent with field instrumentation.
5. The PAGs that will be in use following an RDD/IND incident will be dose based whereas the current PRG calculator is risk based.
6. Scientific review process lacks transparency and scientific rigor consistent with OMB requirements.
7. Protocol for combining multiple PRG values is not well described.

Given these issues and limitations, the use of the SPRG and BPRG calculators for OEM Operations following an RDD or IND long-term recovery scenario is not recommended. These findings suggest that the peer review process was not commensurate with OMB requirements for government documents that may be “highly influential scientific assessments” in setting national policy. OEM should use caution when referring to these tools for any removal action involving radioactive materials, especially after an RDD or IND terrorist attack. Several recommendations are provided that could improve these tools making them more applicable to future OEM removal actions.

# 1.0 INTRODUCTION

In 1997, the U.S. Environmental Protection Agency issued guidance for establishing protective cleanup levels for CERCLA sites contaminated with radioactive materials.<sup>1</sup> That guidance reinforced the agency policy that radioactive cleanups are governed by the risk range for all carcinogens established in the [National Oil and Hazardous Substances Pollution Contingency Plan](#) (NCP) when [Applicable or Relevant and Appropriate Requirements \(ARARs\)](#) are not available or not sufficiently protective. Cleanup should generally achieve a level of protection limiting the risk of excess cancers within an exposed population from 1 per 10,000 to 1 per 1,000,000. This is commonly referred to as the “10<sup>-4</sup> to 10<sup>-6</sup> risk range” and is based on all potential exposure pathways (e.g., soil, ground water, surface water, sediment, air, structures) to the reasonable “maximum” exposed individual.

## 1.1 PRELIMINARY REMEDIATION GOALS (PRG)

In 2002, the Office of Emergency and Remedial Response, now called the Office of Superfund Remediation and Technology Innovation (OSRTI), developed a tool called the [Preliminary Remediation Goals](#) (PRGs) calculator for radionuclides. It was designed specifically for Superfund/RCRA programs and employs risk-based methodologies over ones’ lifetime\* to determine preliminary clean-up concentrations.<sup>2</sup> It was developed to address potential human exposures to contaminated air, soils, water, and biota. Seven exposure scenarios† used in these PRGs are:

1. [Residential Soil](#)
2. [Outdoor Worker Soil](#)
3. [Indoor Worker Soil](#)
4. [Agricultural Soil](#)
5. [Tapwater](#)
6. [Ingestion of Fish](#)
7. [Soil to Groundwater](#).

Generally under the NCP, PRGs are risk-based, conservative screening values that can be used to identify areas and contaminants of potential concern, and that either do or do not warrant further investigation. PRGs typically are tools for evaluating and cleaning up contaminated sites. “They are not *de facto* cleanup standards and should not be applied as such; however, they may be helpful in providing long-term targets to use during the analysis of remedial alternatives.”‡

## 1.2 PRELIMINARY REMEDIATION GOALS FOR SURFACES (SPRG)

In January 2009, OSRTI released another tool called the “[Superfund Preliminary Remediation Goals for Radionuclides in Outdoor Surfaces \(SPRG\)](#).” It was designed to help

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\* Lifetime refers to the duration of exposure and the assumed duration varies with the PRG model scenarios. For example, 30 years is assumed for residential soil, residential air, residential tapwater, and fish ingestion scenarios; 25 years is assumed for outdoor worker soil, land use and indoor worker air scenarios; and 70 years is assumed for soil to groundwater pathway.

† A brief description is provided for the respective scenario. The hyperlinks were active and last accessed on December 11, 2009.

‡ Website [http://epa-bprg.ornl.gov/bprg\\_users\\_guide.shtml](http://epa-bprg.ornl.gov/bprg_users_guide.shtml) accessed on December 11, 2009.

risk assessors, remedial project managers, and others involved with risk assessment and decision-making at sites contaminated with hard outside surfaces (e.g., building slabs, outside building walls, sidewalks, and roads).<sup>3</sup> Like the PRGs, the SPRGs were developed specifically for Superfund/RCRA programs and employ risk-based methodologies over ones' lifetime to determine preliminary clean-up concentrations. The recommended SPRG's role in site "screening" is to help identify areas, contaminants, and conditions that do not require further federal attention at a particular site. Generally, at sites where contaminant concentrations fall below SPRGs, no further action or study is warranted under the Superfund program. Radionuclide concentrations above the SPRG would not automatically designate a site as "dirty" or trigger a response action. However, exceeding an SPRG suggests that further evaluation may be warranted to determine potential risks posed by site contaminants.

### 1.3 PRELIMINARY REMEDIATION GOALS FOR RADIONUCLIDES IN BUILDINGS (BPRG)

The [Preliminary Remediation Goals for Radionuclides in Buildings \(BPRG\)](#) tool is similar to PRGs and SPRGs that employ risk-based concentrations used for Superfund/RCRA programs. Although this tool has been posted to the EPA website, it is not clear if there has been an official Memorandum announcing its release. Generally, these recommended BPRGs are radionuclide concentrations in dust, air and building materials that correspond to a specified level of human cancer risk. The exposure scenarios used in the BPRGs are the [Residential](#) and [Indoor Worker](#) scenarios.

## 2.0 PURPOSE

**The purpose of this report is to assess the practical application of these calculators during an emergency response and long-term recovery following a terrorist attack involving a radiological dispersal device (RDD) or improvised nuclear device (IND).**

There are ongoing EPA internal discussions concerning the use of these tools and the CERCLA Superfund risk-range in setting initial or final clean-up levels *following an RDD or IND terrorist attack*. The discussions focus on two opposing perspectives and their application to long-term recovery scenario *following an RDD/IND attack*.

- One perspective is to use the PRG tools developed for the CERCLA Superfund program to select clean-up levels.
- The other perspective is to implement the Multi-Agency document published by the Department of Homeland Security (DHS) specifically developed to address RDD and IND attacks.

In August 2008, DHS issued its final guidance entitled: "[Planning Guidance for Protection and Recovery Following Radiological Dispersal Device \(RDD\) and Improvised Nuclear Device \(IND\) Incidents](#)." It was a multiagency effort (including EPA) and provides numeric guidelines for the early and intermediate phases as the triggers for taking certain protective actions.<sup>4</sup> For the late phase, rather than establishing numeric cleanup standards, the guidance describes a process that should be used to determine final cleanup standards – the "Optimization" process. Optimization is a shared project management tool to guide the final cleanup from an RDD/IND event. It is a forward-looking iterative process aimed at

preventing exposures before they occur. Technical, and socio-economic factors are considered and qualitative and quantitative judgments are made through this systematic and carefully structured process to ensure all relevant aspects are taken into account. Optimization is a "best-fit solution", always questioning whether the best has been done in the prevailing circumstances. Due to its subjective nature, there is a strong need for transparency and traceability of all decisions made throughout the process.<sup>5</sup> It involves reaching decisions on priorities for cleanup, methods for cleanup, appropriate cleanup levels, and other related remediation decisions, and promotes the input of technical experts and community stakeholders.

### 3.0 GOAL

The goal of this document is to provide scientific and technical information to senior EPA management concerning these two perspectives and their impact on agency responses to *RDD/IND terrorist attacks*. It is not intended to affect the decision-making process associated with existing CERCLA/Superfund sites (e.g., non-terrorist related radioactively contaminated sites). This information may also be useful for (1) the decision-making process associated with long-term clean-up follow RDD/IND attacks and (2) addressing concerns raised by special interest groups.

## 4.0 BACKGROUND

### 4.1 CANCER RISK MANAGEMENT PARADIGMS

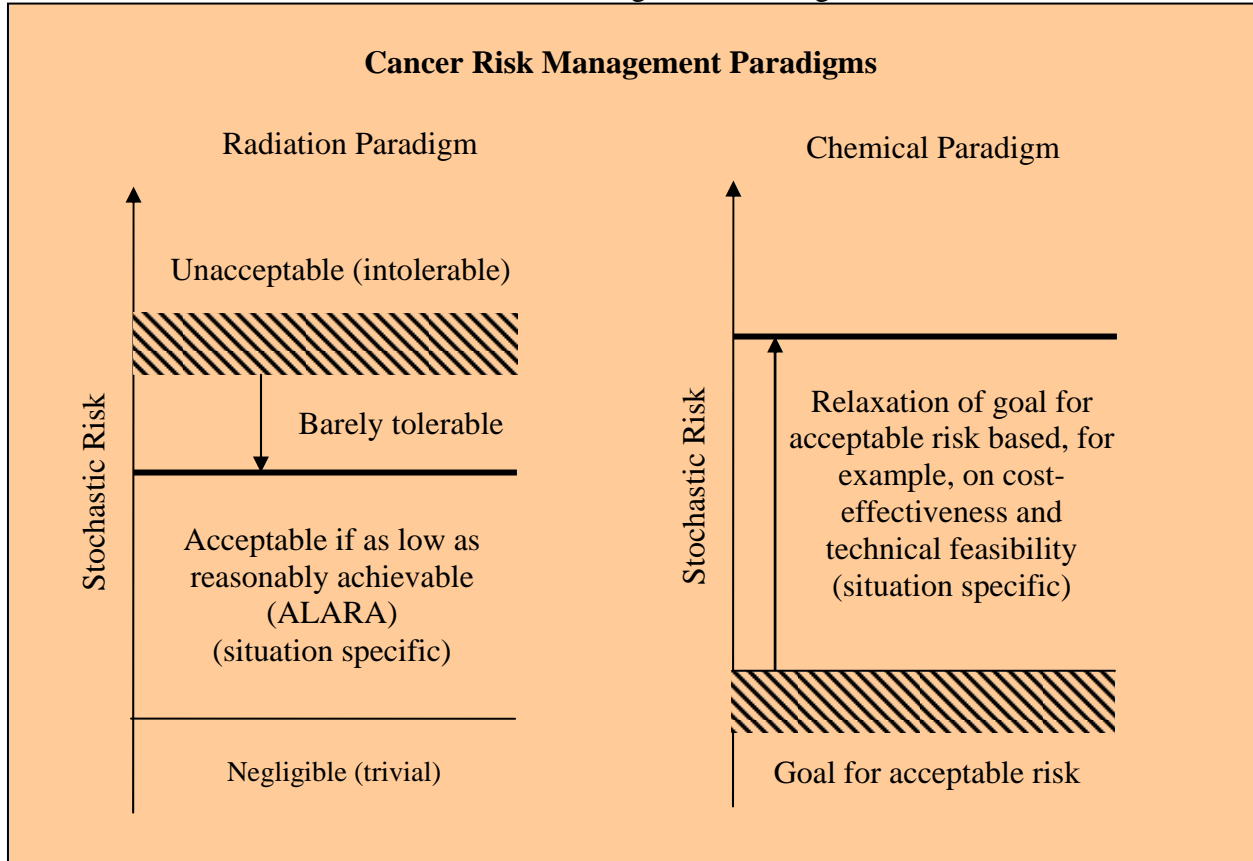
The reason for these opposing perspectives is due to a fundamental difference in the approaches of managing risks (Figure 1). The **radiation paradigm** approach to control radiation exposures of the public is actually a *risk-based* system based on principles developed over many decades by the International Commission on Radiological Protection (ICRP) and the National Council on Radiation Protection and Measurements (NCRP).<sup>6</sup> These principles are:

- (1) **JUSTIFICATION**: the need to justify any radiation exposures on the basis that the benefits to society exceed the overall societal cost; it is this concept that precludes the inclusion of medical doses from the calculation of excess risk.
- (2) **ALARA (Optimization)**: maintain any exposures as low as reasonably achievable, economic and social factors being taken into account; and
- (3) **LIMITATION**: radiation exposures are kept to levels of *acceptable risk*.

These same principles serve as the basis for the EPA dose limitation system<sup>7</sup>.

The principles of ALARA (Optimization) and LIMITATION can be viewed as a "top-down" approach to limit radiation exposure and health risk. Therefore, radiation exposures are considered acceptable if they are less than a specific limit AND they are as low as reasonably achievable. Compliance with a dose limit alone does not define acceptable exposures or risk. This is often misinterpreted by special interest groups that use a single dose number in their arguments and choose to ignore the ALARA component of this paradigm.

**Figure 1**  
Cancer Risk Management Paradigms



Adapted from NCRP Report No. 146. Approaches to Risk Management in Remediation of Radioactively Contaminated Sites.

The **chemical paradigm** approach can be viewed as a “bottom-up” approach to control radiation exposures. The historical use of this paradigm by the EPA is based on the Delaney Clause of the Federal Food, Drug and Cosmetic Act Food Additives Amendment of 1958. This clause set a standard of *zero* risk to the public from carcinogenic food additives, (e.g., pesticides) that concentrate in processed foods. This was interpreted in terms of a “negligible” but nonzero lifetime cancer risk of  $10^{-8}$ , which was later increased to  $10^{-6}$  due to pesticide measurement difficulties at levels corresponding to the lower risk. This lifetime cancer risk criterion and the concept of risk goals were later incorporated into various EPA regulations (e.g., SDWA, CAA, CERCLA, and RCRA). This paradigm has two basic elements:

- (1) A goal for acceptable risk; and
- (2) Allowance for an increase (relaxation) in risks above the goal, based primarily on considerations of technical feasibility and cost.

CERCLA and NCP specify goals for remediation of contaminated sites that are consistent with a lifetime excess cancer risk range  $10^{-6}$  to  $10^{-4}$ . The NCP contains six provisions for waiving the remediation goals if an ARAR cannot be met.\*

- (1) The alternative is an interim measure and will become part of a total remedial action that will attain the ARAR;
- (2) Compliance with the requirement will result in greater risk to human health and the environment than other alternatives;
- (3) Compliance with the requirement is technically impracticable from an engineering perspective;
- (4) The alternative will attain a standard of performance that is equivalent or limited through use of another method or approach;
- (5) With respect to a state requirement, the state has not consistently applied, or demonstrated the intention to consistently apply, the promulgated requirement in similar circumstances at other remedial actions within the state; or
- (6) For Fund-financed response actions only, an alternative that attains the ARAR will not provide a balance between the need for protection of human health and the environment at the site and the availability of Fund monies to respond to other sites that may present a threat to human health and the environment

**Therefore this paradigm sets goals to be met only if it is judged reasonable to do so.** Determining what is reasonable is subject to many views, especially from special interest groups.

In the event of an RDD/IND attack, the long-term clean-up activities may have a larger impact on the surrounding communities, cities, and region where factors other than potential radiation exposure may become the driving force behind the final clean-up levels. For example, psychosocial, economic, and speed-of-recovery issues all affect the long-term viability and survivability of the affected area. Risks associated with moving an entire population on a temporary or permanent basis may be higher than allowing some low-level exposures from residual contamination. Non-destructive clean-up technologies may prove to be too costly or applicable to only small portions of the recovery effort. Overall costs could become so expensive as to reduce the ability to protect human health and the environment if there are multiple areas involved in the attack. Given the potential scope and urgency of the situation following an RDD/IND attack, a practical application of PRGs may not allow the agency the flexibility to account for these special circumstances. **The preference to work towards an acceptable clean-up level (radiation risk paradigm) rather than having to raise a preliminary clean-up goal (chemical risk paradigm) has many political, economic, and societal benefits.**<sup>†</sup>

Following an RDD/IND terrorist attack, both paradigms warrant equal consideration. The radiation risk paradigm was included in the final DHS guidance with EPA and other Federal

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\* 40 CFR 300.430(f)(1)(ii)(C)

<sup>†</sup> California requires that the Santa Susana site be cleaned up to the  $10^{-6}$  risk level. Special interest groups were able to use the agency's Superfund policy and its chemical-risk paradigm to enforce unattainable and immeasurable clean-up levels. This represents a misuse and misinterpretation of the PRG calculators as described in the agency's website.

agencies concurrence. The chemical risk paradigm is routinely used at Superfund sites. They both employ risk-based methods and can lead to similar clean-up levels, however, the chemical-risk paradigm applied to a radiological site is more susceptible to abuse by special interest groups by applying pressure to the agency to achieve its published  $10^{-6}$  PRGs that cannot be measured or statistically show any health benefit to society. For example, the PRGs are based on a  $10^{-6}$  to  $10^{-4}$  excess cancer risk range corresponding to lifetime cumulative doses of about 1 mrem to about 125 mrem above background respectively. Epidemiological analyses indicate that risks of radiation-induced health effects are either nonexistent or too small to be observed from a lifetime cumulative dose below 10,000 mrem above background.<sup>10</sup> Further, risk is a metric that cannot be measured; only radiation exposure or radioactive surface contamination can be measured. Using the PRG calculators to meet the CERCLA risk range suggests that the agency knows the risk with a much greater certainty than is scientifically possible. The NCRP conducted a review of how these risk paradigms are applied and concluded that by focusing on the needs and realities of practical decision making at specific sites and by undertaking the decision-making process in a spirit of cooperation, differences between them should be recognized as unimportant.<sup>8</sup>

## 4.2 EQUATING RISK TO DOSE

The ICRP first introduced the *risk-based* system in the mid-1970s when it adopted the linear-no-threshold model as the foundation for setting occupational and public dose limits.<sup>6</sup> ICRP derived the occupational dose limits based on the average *annual* fatal accident rate in industry of  $10^{-4}$  per year (range between  $0.2 \times 10^{-4}$  to  $5 \times 10^{-4}$  per year). This represents a *lifetime* fatal accidental risk of  $2.5 \times 10^{-2}$  (50 years  $\times$   $5 \times 10^{-4}$  per year using the worst case scenario for accidental death in a safe industry). The ICRP recommended an occupational dose limit of 10 rem over 5 years and no more than 5 rem in any single year.<sup>9</sup> Using these limits, in combination with the ALARA principle, NCRP estimated a uniform dose to workers of 1.36 rem per year.<sup>\*</sup> Assuming a working career of 47 years (ages 18 to 64), the estimated cumulative dose is about 64 rem. Under this scenario, the ICRP and NCRP estimated an excess *lifetime* fatal risk of about  $2.5 \times 10^{-2}$  ( $1.36 \text{ rem/yr} \times 47 \text{ yr} \times 4 \times 10^{-4} \text{ per rem}$ )<sup>†</sup>, which is equivalent to the lifetime risk of accidental death in industry.

The recommended dose limits for members of the public are derived from the occupational dose limits using safety factors.<sup>‡</sup> First, a safety factor of 10 was applied resulting in a maximum dose limit 500 mrem per year ( $5,000 \text{ mrem} / 10 = 500 \text{ mrem}$ ; assuming infrequent exposures). The NCRP then recommended an additional safety factor of 5 ( $500 \text{ mrem} / 5 = 100 \text{ mrem per year}$ ) to account for frequent or continuous exposures from *all potential sources*. Finally, they applied another safety factor of 4 ( $100 \text{ mrem} / 4 = 25 \text{ mrem per year}$ ) to limit exposures from any *single source or set of sources under one control*.<sup>§</sup> Each

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<sup>\*</sup> 5 rem received each year at age 18 through 21, 2 rem at age 22 and 1 rem per year from age 23 through 64. The cumulative dose is 64 rem. ( $64 \text{ rem} / 47 \text{ yr} = 1.36 \text{ rem/yr}$ )

<sup>†</sup>  $4 \times 10^{-4}$  per rem is the NCRP recommended lifetime risk of fatal cancer for workers.

<sup>‡</sup> The application of safety factors is common among many professions (e.g., toxicology, industrial hygiene) to account for uncertainties. For example, a safety factor of 10 is often used to account for extrapolating adverse health effects in mice to humans in toxicological studies.

<sup>§</sup> A superfund site could serve as an example of a single source. A city impacted by an RDD or IND may also serve as a single source or could have multiple sources based on access or land use applications.

recommendation from 500 mrem per year to 25 mrem per year combined with the ALARA principle is further supported by the Health Physics Society.<sup>10</sup>

It is important to note that the actual occupational and public exposures should always be lower than the dose limits by applying the JUSTIFICATION and ALARA principles.<sup>11</sup> Overall, the objective of the ICRP and NCRP dose-limit recommendations is to control the *lifetime fatal risk* to the maximally exposed individuals. In contrast, the objective of the EPA is to limit the *lifetime excess cancer risk* to the “reasonably maximum exposed individual”. This difference effectively represents another safety factor of about 2 (lifetime fatal risk is about  $4 \times 10^{-7}$  per mrem; lifetime excess cancer risk is about  $8 \times 10^{-7}$  per mrem).

In total, a combined safety factor of 400 ( $10 \times 5 \times 4 \times 2$ ) applied to the occupational dose limit results in a public dose limit of 12.5 mrem per year ( $5,000 \text{ mrem per year} / 400 = 12.5 \text{ mrem per yr}$ ). This is equivalent to using the chemical-risk paradigm approach adopted by the EPA in its regulations, where EPA determined that 15 mrem per year\* was equivalent to a lifetime excess cancer risk of  $3 \times 10^{-4}$  which is accepted to be equivalent to the upper risk range of  $10^{-4}$  for CERCLA sites.<sup>12</sup>

#### 4.3 RDD AND IND

The NCRP defines an RDD as a “device designed to spread radioactive material through a detonation of conventional explosives or other (non-nuclear) means”.<sup>13</sup> Generally, RDDs are anticipated to use one of a small number of radioactive materials deemed suitable for the task. An IND is expected to be a homemade nuclear weapon with a yield comparable to that used on Hiroshima or Nagasaki, with the consequences far exceeding that of an RDD. In the area immediately surrounding an IND detonation, structural devastation and human casualties would be tremendous. In addition, residual radioactivity from IND detonation likely would be far more extensive than anticipated for RDD events.

The following radionuclides were selected for analysis because of their potential to be used in an RDD or have been listed as the primary contaminant of concern on EPA Superfund sites.<sup>14</sup>

- Cobalt (Co-60)
- Cesium (Cs-137)
- Iridium (Ir-192)
- Polonium-210 (Po-210)
- Radium (Ra-226)
- Strontium (Sr-90)
- Thorium (Th-232)
- Uranium (U-235 and U-238)

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\* 15 mrem per year is based on a 30 year exposure period. 12.5 mrem per year is based on a 47 year exposure period.

## 4.4 ALTERNATIVE BENCHMARKS FOR RESIDUAL RADIATION

Several organizations have developed criteria for release of materials with low levels of radionuclide contamination. These various organizations have developed criteria based on expected dose or other technical considerations. What follows is a summary of these benchmark release criteria.

### 4.4.1 ANSI H13.12

The purpose of this standard is to provide guidance for protecting the public and the environment from radiation exposure by specifying a primary radiation dose criterion of no more than 1 mrem/yr (0.01 mSv/yr) and derived screening levels for the clearance\* of items that could contain radioactive materials.<sup>15</sup> The guidance provided in this document may be applicable to EPA field operations following an RDD/IND terrorist attack and can serve as a reasonable benchmark for response. Table 1 contains the ANSI 13.12 clearance values.

Table 1

ANSI H13.12

ANSI H13.12 Screening Levels for Clearance			
Radionuclide Group	Screening Levels (S.I. Units)	Surface Screening (Conventional Units)	Volume Screening (Conventional Units)
	Bq/cm <sup>2</sup> or Bq/g	(dpm/100 cm <sup>2</sup> )	(pCi/g)
<u>Group 1</u> Radium, Thorium, and Transuranics and High Dose Photon Emitters: <sup>60</sup> Co, <sup>137</sup> Cs ( <sup>137</sup> Ba), Am-241,	0.1	600	3
<u>Group 2</u> Uranium and Selected High Dose Beta-Gamma Emitters: <sup>192</sup> Ir, <sup>90</sup> Sr,	1	6,000	30
<u>Group 3</u> General Beta-Gamma Emitters:	10	60,000	300
<u>Group 4</u> Other Beta-Gamma Emitters:	100	600,000	3,000
<u>Group 5</u> Low Dose Beta Emitters	1,000	6,000,000	30,000

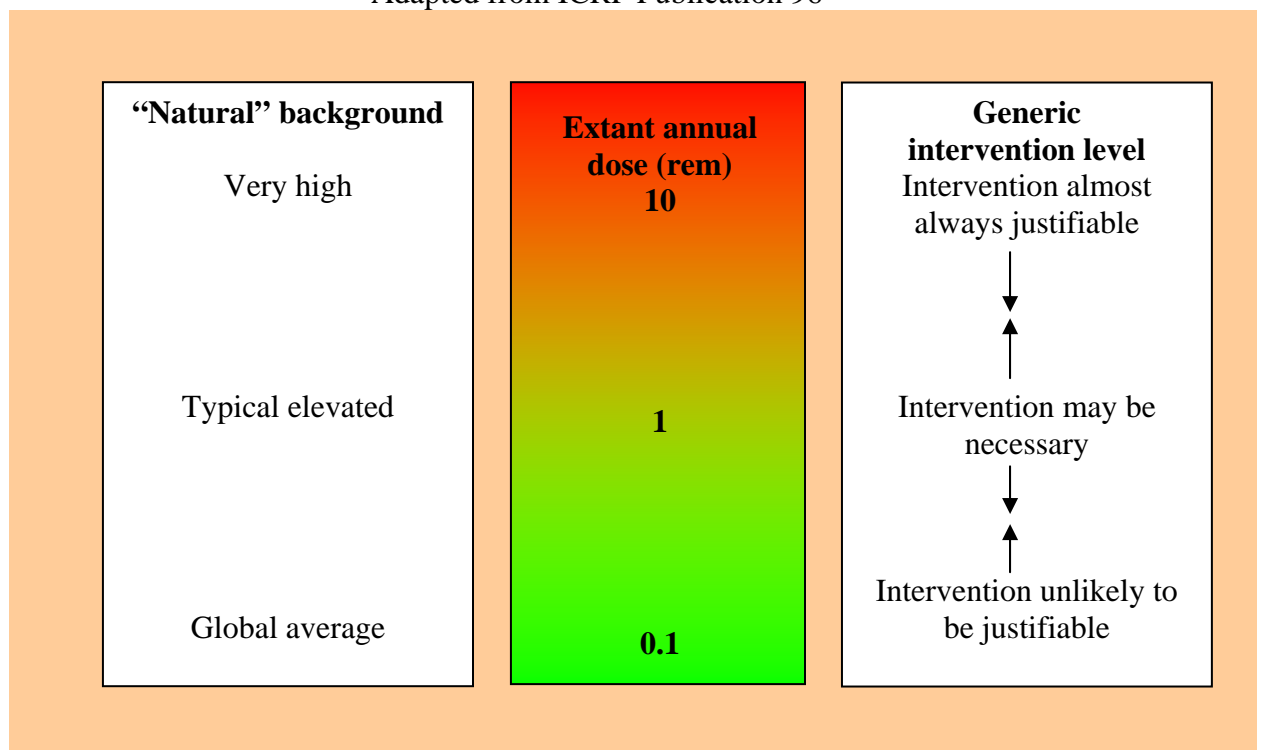
\*The above table is for illustrative purposes only. Consult the original document for all pertinent details and assumptions.

\* Clearance in this context means the removal of items or materials that contain residual levels of radioactive materials within authorized practices from any further control of any kind.

#### 4.4.2 ICRP Operational Levels

Operational intervention levels are similar to the EPA Protection Action Guides, in that they correspond to action levels that determine the appropriate protective actions on the basis of environmental measurements. They differ in that the ICRP provides numerical guidelines for long-term recovery whereas the current [EPA PAG Manual](#) does not (Figure 2). In a long-term recovery, if full contamination is not feasible after an RDD/IND attack, the long-term aftermath can result in prolonged exposures caused by the remaining radioactive residuals. ICRP Publication 82 provides specific guidance (e.g., contaminated consumer goods, commodities, bulk materials, food, water supplies, hot particles, corpses, and controlling the area) on how to apply these recommendations for protecting the public in the long-term. Generic reference levels in terms of the existing annual dose are used to justify further actions. ICRP stresses that these levels be used with extreme caution. For example, *if some controllable components of the existing annual dose are clearly dominant, these generic reference levels should not prevent further protective actions from being taken to reduce those dominant components.*<sup>16</sup> This is consistent with their ALARA principle.

**Figure 2.**  
Generic Interventional Levels for Long-Term Recovery Situations  
Adapted from ICRP Publication 96



The protective action required following an RDD or IND will generally be disruptive and restrictive to 'normal' living conditions. Eventually, clean-up activities may need to be stopped, and in some situations, the background radiation levels may be higher than before the event as a result of the residual contamination that may be difficult or impossible to remove. The easiest justification for stopping clean-up activities is to confirm that the exposures have decreased below site specific action levels that prompted the intervention. If it is not feasible to attain the site-specific clean-up levels, then the generic reference level below which intervention is unlikely to be justified (100 mrem / yr), could provide a basis for discontinuing the intervention. This is also supported by the Health Physics Society.<sup>10</sup>

ICRP also recognizes that the exposed population may find it unacceptable to stop the protective actions, and that the social pressures may override the benefit of discontinuing the intervention. In this case, participation of the stakeholders in the decision-making process becomes essential in agreeing to endpoints at the beginning of the clean-up activities. The process of achieving an acceptable clean-up level should be:

- **Transparent** – the basis for clean-up decisions should be available to the public,
- **Inclusive** – representative interested parties should be involved in decision making activities,
- **Effective** – technical subject matter experts should analyze clean-up options including considerations for minimizing waste volumes, consider appropriate benchmarks, assess various technologies to find the best solution for the incident, and design a monitoring program before, during and after the clean-up activities to substantiate the results, and
- **Shared accountability** – the final decision to proceed will be made jointly by all decision makers.

#### 4.4.3 NRC Regulatory Guide 1.86<sup>17</sup>/DOE Order 5400.5<sup>18</sup>

The NRC and the DOE have developed limits for surface contamination for unrestricted release of contaminated materials. These values are similar to the ANSI 13.12 values, but have limits on removable, average and maximum contamination levels. Like the ANSI standard, the NRC limits have developed classes of radionuclides. Unlike the ANSI standards, these standards are not dose based; rather they reflect the equipment capabilities of the time. These values are still in use today and they compare favorably with the ANSI 13.12 screening levels.

Table 2

NRC Regulatory Guide 1.86/DOE Order 5400.5

<b>Allowable Surface Contamination</b>			
<b>NUCLIDE</b>	<b>AVERAGE</b> (dpm/100 cm <sup>2</sup> )	<b>MAXIMUM</b> (dpm/100 cm <sup>2</sup> )	<b>REMOVABLE</b> (dpm/100 cm <sup>2</sup> )
U-nat, U-235, U-238 and associated decay products	5000	15000	1000
Transuranics, Ra-226, Ra-228, Th-230, Th-228, Pa-231, Ac-227, I-125, I-129	100	300	20
Th-nat, Th-232, Sr-90, Ra-223, Ra-224, U-232, I-126, I-131, I-133	1000	3000	200
Beta-gamma emitters (nuclides with decay modes other than alpha emission or spontaneous fission) except Sr-90 and others noted above.	5000	15000	1000

\*The above table is for illustrative purposes only. Consult the original document for all pertinent details and assumptions.

#### 4.4.4 DHS Planning Guidance

The Department of Homeland Security (DHS) addresses the issue of residual contamination in its “[Planning Guidance for Protection and Recovery Following Radiological Dispersal Device \(RDD\) and Improvised Nuclear Device \(IND\) Incidents](#)” August 2008.<sup>19</sup> In this document it proposes guideline preparation for seven distinct groups. The approach differs from other benchmarks by providing radionuclide specific values based on scenarios, assumptions on land use, and other future applications of the contaminated area. The guidance establishes the [RESRAD RDD](#) code as the protocol for developing incident specific guideline values. This code can be used to provide surface contamination levels associated with a 100 mrem per year dose and a 4 mrem per year dose for water contamination. The following scenarios are built into the model:

1. Access control during emergency response
2. Early-phase protective action
3. Relocation and critical infrastructure use in relocation areas
4. Temporary access to relocation areas for essential activities
5. Transportation and access routes
6. Release of property from radiologically controlled areas
7. Food consumption.

#### 4.4.5 EPA SHEMP Manual

The EPA SHEMP Guidance 38 document provides EPA personnel with strategies on how to work safely with nuclear materials and radiation producing equipment. It addresses many aspects of a Radiation protection program and supports the ALARA principle of radiation protection. The SHEMP manual position on dose limitation contains three important principles. These are nearly identical to the ICRP position. They include the following:

1. Justification – there should not be any planned occupational exposure of workers to ionizing radiation without the expectation of an overall benefit from the activity causing the exposure.
2. Optimization – a sustained effort should be made to ensure that collective doses, as well as annual, committed, and cumulative lifetime individual doses, are maintained ALARA, economic and social factors being taken into account.
3. Limitation – radiation doses received as a result of routine and/or emergency occupational exposure should not exceed the Administrative Control Level (ACL) established under this Program.

Thus the EPA SHEMP program clearly follows the ICRP radiological paradigm for protection of its workers.

The above benchmarks are presented as background information indicative of various methods used in the U.S. for release of radiologically contaminated sites. The remainder of this report concerns itself with the workings of the EPA calculators under consideration.

## 5.0 HISTORICAL REMEDIATION CLEANUP LEVELS LITERATURE SEARCH

A literature search was conducted to summarize historical remediation cleanup levels approved for EPA sites contaminated with radionuclides anticipated to be used in RDDs. A literature search of Records of Decision (ROD) listed on the EPA website located at <http://cfpub.epa.gov/superrods/index.cfm> yielded the 33 RODs considered in this report (Table 3). These RODs contained contaminants of concern (COC) similar to those anticipated for an RDD event. The RODs were reviewed to determine the following:

- Contaminants of concern
- Associated cleanup levels
- Media involved (typically soils)
- Decision basis (specified dose equivalent or excess cancer risk)
- Decision criterion (dose, risk, or a combination of both)
- Receptors (such as resident or industrial worker)
- Where specified, evaluation method (such as sampling surveys, etc.)

**TABLE 3**  
**HISTORIC CLEANUP VALUES AT EPA SUPERFUND SITES**

COC	Site	Cleanup Level (pCi/g unless otherwise noted)	Cleanup Decision <sup>a</sup>	Receptor <sup>b</sup>	Dose- or Risk-based <sup>c</sup>	Evaluation Method <sup>d</sup>
Co-60	BNL <sup>20</sup>	3,356	-	Industrial Use	Both	-
	Hanford Reactor <sup>21</sup>	1.4	15 mrem	Frequent Use/ Resident	Dose	Sampling
Cs-13	ANL <sup>22</sup>	23.3	15 mrem	-	Dose	-
	INEEL <sup>23</sup>	11.3	1E-04	Outdoor Worker	Risk	Sampling
	BNL <sup>20</sup>	67	15 mrem/ 1E-04	Industrial Use	Both	Soil Sampling/ Surveys
	SRS <sup>24</sup>	2.79	1E-06	Future Resident	Risk	-
	SRS <sup>24</sup>	1.04	1E-06	Future Worker	Risk	-
	Hanford Reactor <sup>21</sup>	6.2	15 mrem	Frequent Use/ Resident	Dose	Sampling
Ir-192	NRC Screening <sup>25</sup>	41	-	-	-	-
Po-210	Fernald <sup>26</sup>	78	1E-06	Trespasser	Risk	-
	UK Response	60,000 dpm / 100 cm <sup>2</sup>	100 mrem / yr	Residential	Dose	Field Measurements
Ra-226	Montclair, NJ <sup>27</sup>	5/15	40 CFR 192	Presumed Residential	Dose	-
	Glen Ridge, NJ <sup>28</sup>	5/15	40 CFR 192	Presumed Residential	Dose	-
	Radium Chemical Co. <sup>29</sup>	5/15	40 CFR 192	Presumed Residential	Dose	-
	US Radium, Orange, NJ <sup>30</sup>	5/15	40 CFR 192	Presumed Residential	Dose	-
	Lansdowne, PA <sup>31</sup>	5/15	40 CFR 192	Presumed Residential	Dose	-
	Austin Ave., Delaware City, PA <sup>32</sup>	5/15	40 CFR 192	Presumed Residential	Dose	-
	Weldon Springs, MO <sup>33</sup>	6.21	1E-06	Passerby/ Trespasser	Risk	-
	Denver Sites <sup>34</sup>	5/15 + background	-	-	-	-
	COE Linde Site <sup>35</sup>	1,000 dpm/110 cm <sup>2</sup>	-	-	-	-
	Colorado School of Mines <sup>36</sup>	4.14	-	Urban Resident/ Recreational User	-	-
	El Toro <sup>37</sup>	1.558	25 mrem	Resident Farmer	Both	Soil Sample/ Survey
Sr-90	BNL <sup>20</sup>	15	-	Industrial Use	Both	-
	Hanford Reactor <sup>21</sup>	4.5	15 mrem	Frequent Use/ Resident	Dose	Sampling
Th-232	COE Linde Site <sup>35</sup>	1,000 dpm/110 cm <sup>2</sup>	-	-	-	-
	NASA <sup>38</sup>	5	3.2E-04	Resident	Risk/ALARA	Sampling/ Survey
	Oak Ridge <sup>39</sup>	5	3.2E-04	Outdoor Worker	Risk/ALARA	Sampling/ Survey
	Hanford Reactor <sup>21</sup>	1.3	15 mrem	Frequent Use/ Resident	Dose	Sampling
U	COE Linde Site <sup>35</sup>	5,000 dpm/100 cm <sup>2</sup>	-	-	-	-
U-235	BNL <sup>20</sup>	29	-	Industrial Use	Both	-
	Hanford Reactor <sup>21</sup>	1	15 mrem	Frequent Use/ Resident	Dose	Sampling
U-238	Weldon Springs, MO <sup>33</sup>	120	-	Passerby/Trespasser	-	-
	BNL <sup>20</sup>	11	-	Industrial Use	Both	-
	Hanford Reactor <sup>21</sup>	1.1	15 mrem	Frequent Use/ Resident	Dose	Sampling
U (natural)	Denver Sites <sup>34</sup>	75	-	-	-	-

Notes:

- Information could not be determined from ROD  
ALARA As low as reasonably achievable

ANL  
BNL

Argonne National Laboratory  
Brookhaven National Laboratory

CFR	<i>Code of Federal Regulations</i>	INEEL	Idaho National Engineering and Environmental Laboratory
COC	Chemical of concern	mrem	Millirem
COE	U.S. Army Corps of Engineers	NASA	National Aeronautics and Space Administration
cm <sup>2</sup>	Square centimeter	pCi/g	Picocurie per gram
DOE	U.S. Department of Energy	SRS	Savannah River Site
dpm	Disintegration per minute		
a	The cleanup decision generally is based on either dose per year or excess risk of cancer. When it was possible to determine which criterion was used, it is noted here. In some cases, both dose and excess cancer risk were considered.		
b	Different receptors were used to calculate the reasonably maximally exposed individual. Generally, a residential receptor has the highest dose or risk because of greater exposure times.		
c	This column indicates whether the cleanup decision was dose- or risk-based. At some sites, both criteria were used. Also, at some sites, excess cancer risk was considered but outside of the typical 1E-06 to 1E-04 range based on ALARA considerations noted as "Risk/ALARA" in this column.		
d	The evaluation method is used to indicate measurements used to evaluate whether the site met cleanup goals. Typically, methods include sampling (and subsequent laboratory analysis) or survey instrumentation readings.		

The review of the RODs associated with these 33 sites indicates that most cleanup criteria were based on soil contamination. The cleanup criteria historically have been decided using many methods, including dose-based standards promulgated in Title 40 of the *Code of Federal Regulations* (CFR), Chapter 192; risk- or dose-based standards; or a combination of risk- and dose-based standards. Of the 33 sites evaluated, information for 26 sites included the method used to determine the cleanup criteria. In addition, the observations summarized below were made:

- 40 CFR 192 dose-based standards were applied at six sites. These sites involved remediation of Ra, Th, U, and their daughter products.
- Risk-based standards were applied at five sites.
- Risk-based / as-low-as-reasonably-achievable (ALARA) standards were applied at two sites.
- Dose-based standards other than 40 CFR 192 standards were applied at seven sites.
- At six other sites, both risk- and dose-based cleanup criteria were used.
- Of the 26 sites for which the basis of decision could be determined, risk criteria were used at 14 sites and dose criteria were used at 19 sites (both criteria were used at 7 sites, explaining the overlap).

COC-specific findings from the ROD review are summarized below.

### **Co-60 (cleanup value range 1.4 to 3,356 picoCuries per gram [pCi/g])**

Cleanup criteria for Co-60 were developed for two sites, the Brookhaven National Laboratory (BNL) and the Hanford Reactor site. For the BNL, an industrial worker scenario was used to derive a cleanup level of 3,356 pCi/g. For the Hanford Reactor site, a residential scenario was used to derive a cleanup level of 1.4 pCi/g.

### **Cs-137 (cleanup value range 1.04 to 67 pCi/g)**

Soil cleanup criteria were developed for Cs-137 for five sites. The cleanup criteria ranged from 1.04 pCi/g at the Savannah River Site (SRS) based on a future worker scenario to up to 67 pCi/g at BNL based on an industrial user scenario. It should be noted that the BNL criterion was based

on a 1E-04 risk instead of the usual departure point of 1E-06. For a 1E-06 excess cancer risk, the 67-pCi/g cleanup criterion would correlate to a cleanup criterion of 0.67 pCi/g.

### **Ir-192 (screening value 41 pCi/g)**

No RODs were found specifying cleanup guidelines for Ir-192, although a NRC screening value<sup>24</sup> of 41 pCi/g was found. This screening level was developed for contaminated soils to support the release criteria of Reg. Guide 1.86.

### **Po-210 (cleanup value 78 pCi/g)**

A single site was found with Po-210 as a COC. The Fernald site cleanup criterion for Po-210 was 78 pCi/g.

During the [United Kingdom Po-210 response](#) following the death of [Alexander Letvinenko](#), the UK Health Protection Agency, Radiation Protection Division recommended a value of 10 Bq per cm<sup>2</sup> (60,000 dpm per 100 cm<sup>2</sup>) be used as a reference level for measured levels of fixed surface contamination of Po-210. This value was based on calculations carried out to estimate levels of dose that might be received from exposure to contamination at this level. A number of scenarios were considered involving people of different ages, engaged in a range of behaviors resulting in inhalation of resuspended material, direct entry of contamination into wounds or ingestion of material. On the basis of these assessments, it was expected that any individual would not receive doses exceeding 1 mSv (100 mrem; i.e. the annual dose limit for members of the public), if the contamination was fixed to a hard surface.<sup>40</sup>

### **Ra-226 (cleanup value range 4.14 – 6.21 pCi/g)**

Of the 33 sites and 1 screening level identified, 11 involved Ra-226. Ten of those levels were cleanup values for Ra-226 in soils, of which seven reiterated the 5-pCi/g level promulgated in 40 CFR 192. Two other soil values were also calculated. For a passerby/trespasser at the Weldon Springs site, a cleanup value of 6.21 pCi/g (which was 5 pCi/g above background) corresponded to a 1E-06 excess cancer risk. At the Colorado School of Mines, a cleanup criterion of 4.14 pCi/g was used, but it is unclear whether this criterion was based on dose or risk. The average soil cleanup criterion was 5.0 pCi/g. In addition, one surface cleanup criterion was listed for the U.S. Army Corps of Engineers (COE) Linde site of 1,000 disintegrations per minute (dpm) per 100 square centimeters (cm<sup>2</sup>). It was not clear what scenario was used to establish this clean-up level.

### **Sr-90 (cleanup value range 4.5 to 15 pCi/g)**

Two cleanup criteria were found for Sr-90. Remediation for Sr-90 was conducted at BNL and the Hanford Reactor site. For BNL, the criterion was 15 pCi/g under an industrial-use scenario. The Hanford Reactor criterion was 4.5 pCi/g.

### **Th-232 (cleanup value range 1.3 to 5 pCi/g)**

Three soil criteria and a single surface cleanup criterion were found for Th-232. The soil criterion was 5 pCi/g at both the Oak Ridge and the NASA sites for an outdoor worker and resident, respectively. The surface criterion was 1,000 dpm per 100 cm<sup>2</sup>.

### U-235 (cleanup value range 1 to 29 pCi/g)

The cleanup criterion for U-235 was 1 pCi/g at the Hanford Reactor site assuming residential use and 29 pCi/g at BNL assuming industrial use.

### U-238 (cleanup value range 1.1 to 120 pCi/g)

Cleanup levels for U-238 ranged from 120 pCi/g at the Weldon Springs site based on a passerby or trespasser scenario down to 1.1 pCi/g at the Hanford Reactor site based on a residential-use scenario. Industrial use at BNL resulted in a cleanup level of 11 pCi/g. The COE Linde Site surface cleanup criterion was 5,000 dpm/100 cm<sup>2</sup> of U (isotope not specified).

## 6.0 SPRG CALCULATOR EVALUATION

This section compares the SPRG calculator values to the values in the SPRG website download tables (Section 6.1), SPRG calculator risk-based values to existing standards (Section 6.2), and SPRG calculator values to EPA-approved ROD values (Section 6.3). Section 6.4 discusses SPRG calculator issues.

The soil SPRG calculator values used for comparison are for surface sources (that is, they assume no contamination at depth). These values are used for consistency in comparison and likely represent the most reasonable comparison for events involving an RDD or IND. Contamination of soil, concrete, or asphalt to depth is not considered likely unless significant precipitation occurs, and then only in soil. Values for various receptors under various scenarios were compared to determine the most restrictive cleanup levels. The cleanup guidelines then were compared to historical cleanup levels for soils and to other standards for surface cleanup guidelines as discussed below.

### 6.1 SPRG CALCULATOR VS. WEBSITE DOWNLOAD VALUES

Review of the default SPRG values revealed major discrepancies between the SPRG calculator values and the values downloaded from the SPRG website. **These values should be the same regardless of the method used to obtain the values because both sets of values are for “default” pathways and parameters.** Tables 4 through 7 below compare the download and calculator values. It is not obvious which set should be used for comparison. Because the calculator values typically are much smaller than the download values (and typically the soil cleanup values from the RODs were much lower still), the lower SPRG calculator values were compared to historic cleanup values. Figure 3 is a graphical representation of the ratio of the SPRG calculator to download values. The ratio should be 1 to 1 because the values should be the same numbers, which Figure 3 shows clearly is not the case.

**TABLE 4**

**SPRG DOWNLOAD VS. CALCULATOR VALUES FOR 1E-06 EXCESS CANCER RISK**

Radionuclide	Soil to a depth of 1 centimeter					
	Outdoor Worker		Resident		Indoor Worker	
	Download Value (pCi/g)	Calculator Value (pCi/g)	Download Value (pCi/g)	Calculator Value (pCi/g)	Download Value (pCi/g)	Calculator Value (pCi/g)
Co-60	1.04E+08	4.08E+02	6.43E+07	2.48E+02	2.34E+08	9.18E+02
Cs-137+D	3.05E+07	6.65E+02	1.88E+07	3.61E+02	6.85E+07	1.50E+03
Ir-192	3.32E+08	2.95E+04	2.05E+08	1.82E+04	7.47E+08	6.63E+04
Po-210	4.90E+17	1.54E+09	1.59E+07	9.55E+08	1.10E+18	3.47E+09
Ra-226	3.56E+09	4.18E+04	3.03E+17	2.16E+04	8.02E+09	9.42E+04
Ra-226+D	1.46E+07	1.70E+02	2.21E+09	8.76E+01	3.29E+07	3.82E+02
Sr-90	1.25E+07	1.98E+06	7.74E+06	1.08E+06	2.82E+07	4.46E+06
Sr-90+D	5.93E+07	4.71E+04	3.67E+07	2.56E+04	1.33E+08	1.06E+05
Th-232	2.89E+07	1.55E+06	1.79E+07	8.00E+05	6.51E+07	3.49E+06
U-235	3.94E+04	1.81E+03	2.44E+04	9.32E+02	8.87E+04	4.07E+03
U-238	2.23E+07	5.73E+06	1.38E+07	2.95E+06	5.01E+07	1.29E+07
U-238+D	8.51E+06	9.42E+03	5.26E+06	4.86E+03	1.91E+07	2.12E+04

Note: +D And daughter products

**TABLE 5**

**SPRG “DOWNLOAD” VS. “CALCULATOR” VALUES FOR OUTDOOR WORKER**

Radionuclide	Download Value (pCi/g)	Calculator Value (pCi/g)	Ratio Download/ Calculator
Co-60	1.04E+08	4.08E+02	254,900
Cs-137+D	3.05E+07	6.65E+02	45,864
Ir-192	3.32E+08	2.95E+04	11,253
Po-210	4.90E+17	1.54E+09	318,181,817
Ra-226	3.56E+09	4.18E+04	85,166
Ra-226+D	1.46E+07	1.70E+02	85,881
Sr-90	1.25E+07	1.98E+06	5.31
Sr-90+D	5.93E+07	4.71E+04	1,258
Th-232	2.89E+07	1.55E+06	17.7
U-235	3.94E+04	1.81E+03	20.8
U-238	2.23E+07	5.73E+06	2.89
U-238+D	8.51E+06	9.42E+03	902

Note:

+D And daughter products

**TABLE 6****SPRG “DOWNLOAD” VS. “CALCULATOR” VALUES FOR RESIDENT**

Radionuclide	Download Value (pCi/g)	Calculator Value (pCi/g)	Ratio Download/ Calculator
Co-60	6.43E+07	2.48E+02	259,273
Cs-137+D	1.88E+07	3.61E+02	52,077
Ir-192	2.05E+08	1.82E+04	11,263
Po-210	1.59E+07	9.55E+08	.017
Ra-226	3.03E+17	2.16E+04	14,027,777,777,777
Ra-226+D	2.21E+09	8.76E+01	25,228,310
Sr-90	7.74E+06	1.08E+06	6.17
Sr-90+D	3.67E+07	2.56E+04	1,433
Th-232	1.79E+07	8.00E+05	2.1
U-235	2.44E+04	9.32E+02	2.5
U-238	1.38E+07	2.95E+06	3.68
U-238+D	5.26E+06	4.86E+03	1,081
Co-60	6.43E+07	2.48E+02	259,273

Note:

+D And daughter products

**TABLE 7****SPRG “DOWNLOAD” VS. “CALCULATOR” VALUES FOR INDOOR WORKER**

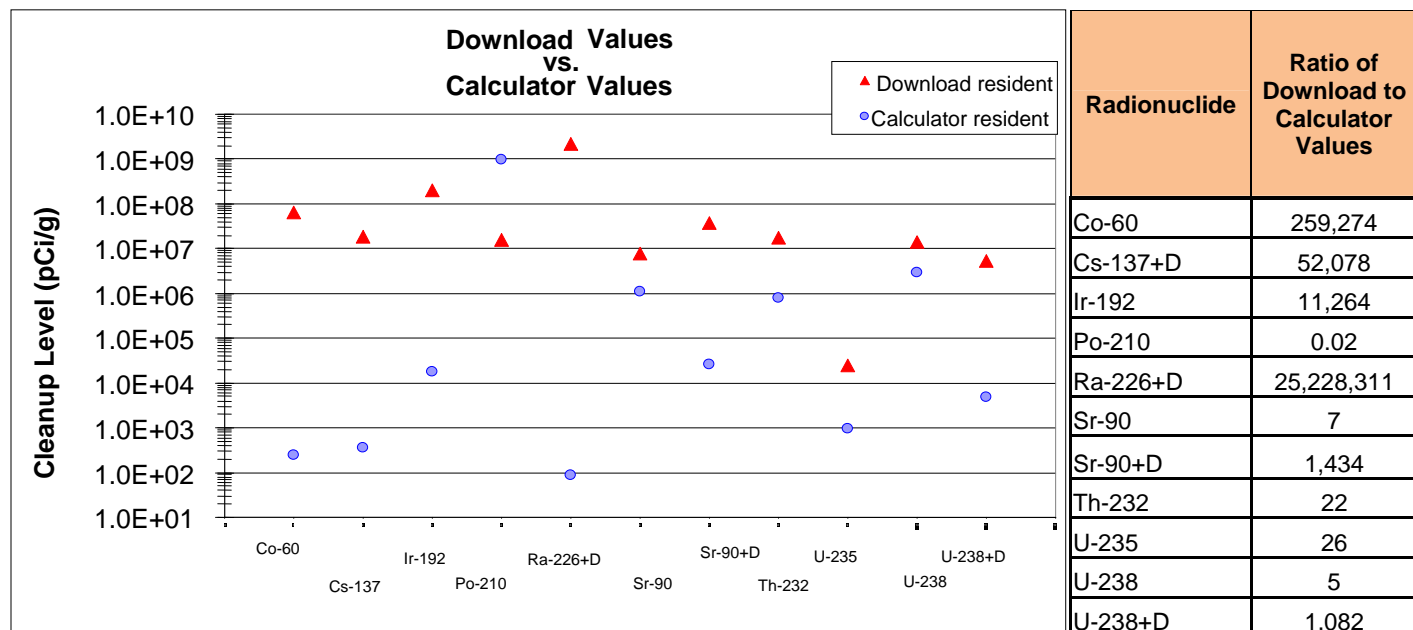
Radionuclide	Download Value (pCi/g)	Calculator Value (pCi/g)	Ratio Download/ Calculator
Co-60	2.34E+08	9.18E+02	254,901
Cs-137+D	6.85E+07	1.50E+03	45,666
Ir-192	7.47E+08	6.63E+04	11,266
Po-210	1.10E+18	3.47E+09	317,002,880
Ra-226	8.02E+09	9.42E+04	85,137
Ra-226+D	3.29E+07	3.82E+02	86,125
Sr-90	2.82E+07	4.46E+06	5.32
Sr-90+D	1.33E+08	1.06E+05	1,254
Th-232	6.51E+07	3.49E+06	17.65
U-235	8.87E+04	4.07E+03	20.79
U-238	5.01E+07	1.29E+07	2.88
U-238+D	1.91E+07	2.12E+04	900

Note:

+D And daughter products

FIGURE 3

### SPRG DOWNLOAD VS. CALCULATOR VALUES FOR RESIDENT



As shown above, most of the download vs. calculator default values varied by several orders of magnitude. **They should be equal to one another.**

## 6.2 SPRG CALCULATOR RISK-BASED VALUES VS. EXISTING STANDARDS

The default SPRG calculator generates results for three types of receptor: the [residential, indoor worker, and outdoor worker receptors](#). The SPRG calculator assumes that each receptor would have slightly different exposure parameters and therefore slightly different remediation guidelines. For example, a resident would have a longer exposure time because more time would be spent in the area of concern, but an outdoor worker would have a higher breathing rate because the outdoor worker would be performing physical labor. In general, the SPRG calculator values for the residential scenario were the lowest (most restrictive) as shown in Table 9. These were compared to the unrestricted release guidelines from the Nuclear Regulatory Commission (NRC) Regulatory Guide 1.86<sup>41</sup>, American National Standards Institute (ANSI) 13.12<sup>42</sup>, and DOE Order 5400.5<sup>43</sup>.

These alternate guidelines make use of a limited number of classes of radionuclides in order to simplify the decision level in the field rather than requiring the calculation of a guideline value for each of the roughly 1,100 individual radionuclides (and daughter combinations) included in the SPRG calculator. Instead of being based strictly on dose, the SPRG calculator values were calculated based on an excess cancer risk of one additional cancer case per million (1E-06). As Table 8 shows, the most restrictive SPRG values were associated with the mechanical resuspension of dust - primarily from vehicular traffic on contaminated roadways. Table 9 lists the PRGs calculated for each of the three receptors from mechanical resuspension. This table shows that the outdoor worker scenario is the most

restrictive of the three scenarios. Therefore, Figure 4 compares the outdoor worker SPRG values to the ANSI 13.12 standards for contaminated surfaces.

As Figure 4 and Table 9 show, the surface guidelines generated by the SPRG calculator are significantly lower than the ANSI 13.12 standards. The SPRG calculator values are two to six orders of magnitude (approximately 100 to 1,000,000 times) more restrictive than the current ANSI 13.12 standards. As stated previously, the ANSI standards were set to correspond to a dose of one millirem per year. This correlates to approximately a  $10^{-6}$  risk of excess cancer. Thus one can argue that the SPRGs provide ultra conservative values corresponding to approximately  $10^{-12}$  excess cancer risk rather than the  $10^{-6}$  excess cancer risk stated in the User Guide for the calculator.

Similarly, the values for surface contamination PRGs were compared to the few values previously available in the RODs. The previously approved values for surface contamination with Ra-226, Th-232 and U were 1,000; 1,000; and 5,000 dpm/100 cm<sup>2</sup>, respectively, for the Corps of Engineers Linde site. The SPRG values for mechanical resuspension are 0.009, 0.002, and 0.011 dpm/100 cm<sup>2</sup>, respectively, which represent a reduction of 100,000 to 500,000 times compared to EPA-approved contamination levels. This further indicates excessive conservatism on the part of the SPRG model.

**TABLE 8**

**SPRG CALCULATOR RESIDENTIAL VALUES VS. EXISTING STANDARDS  
FOR 1E-06 EXCESS CANCER RISK**

Radionuclide	SPRG Values				Existing Standards	
	Resuspension		3-D External <sup>a</sup>	2-D External <sup>b</sup>		
	Wind (dpm/100 cm <sup>2</sup> )	Mechanical (dpm/100 cm <sup>2</sup> )	(dpm/100 cm <sup>2</sup> )	Ground Plane (dpm/100 cm <sup>2</sup> )	DOE 5400.5 /NRC 1.86 (dpm/100 cm <sup>2</sup> )	ANSI 13.12 (dpm/100 cm <sup>2</sup> )
Co-60	17.80	7.26	36	49	5,000	6,000
Cs-137+D	8.86	5.22	51	69	5,000	6,000
Ir-192	1,041.18	321.90	2,575	3,263	5,000	6,000
Po-210	13.74	0.53	136,086,000	186,480,000	-	600
Ra-226	0.26	0.01	3,041	4,240	100 <sup>c</sup>	600
Sr-90	4.73	1.11	66,378	89,910	1,000	6,000
Th-232	0.14	0.002	47,952	69,708	1,000	600
U-235	0.52	0.01	131	177	5,000	6,000
U-238	0.56	0.01	59,052	84,804	5,000	6,000

Notes:

- No standard

+D And daughter products

ANSI American National Standards Institute

cm<sup>2</sup> Square centimeter

a This value is calculated based on immersion in a cloud of resuspended particulates.

b This value is calculated based on "shine" from a plane source.

c This value applies only to NRC 1.86.

DOE U.S. Department of Energy

dpm Disintegration per minute

NRC Nuclear Regulatory Commission

**TABLE 9**

## SPRG CALCULATOR MECHANICAL RESUSPENSION FROM SURFACES VALUES VS. EXISTING STANDARDS FOR 1E-06 EXCESS CANCER RISK

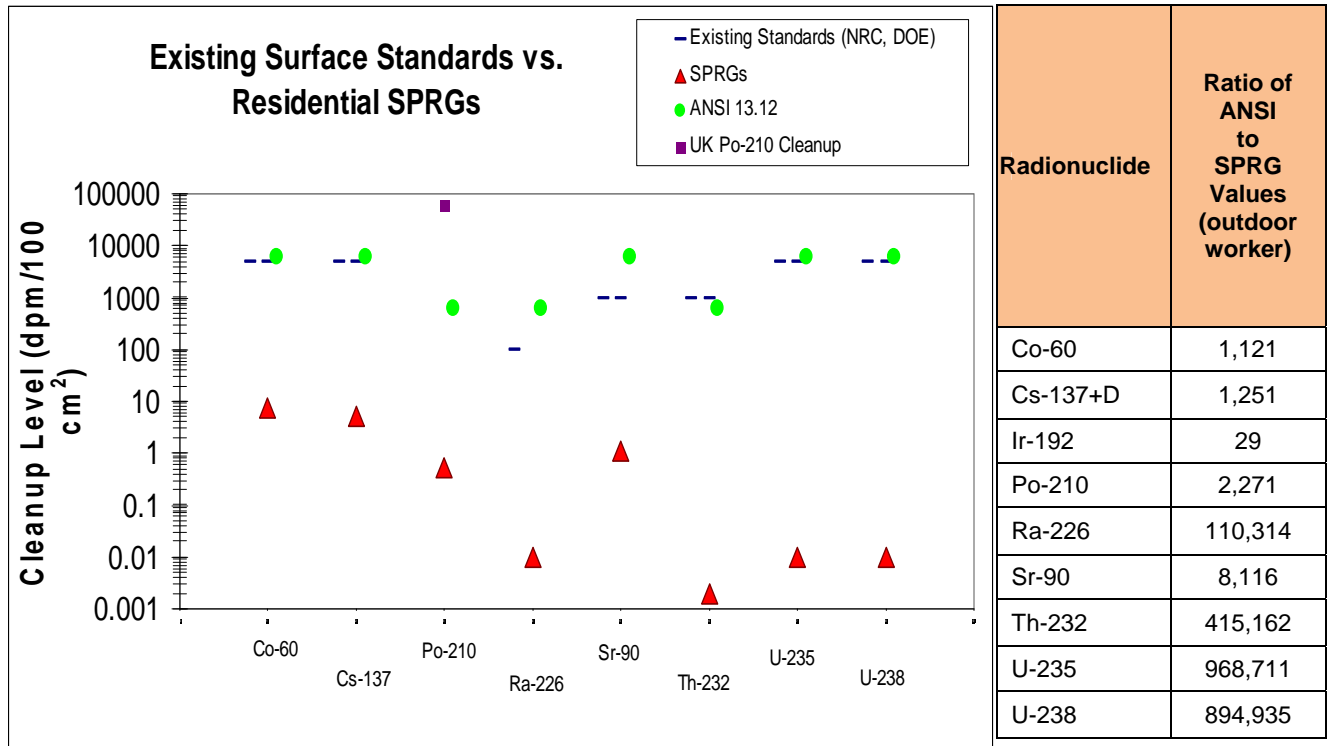
Radionuclide	SPRG Values			Existing Standard		
	Residential Mechanical (dpm/100 cm <sup>2</sup> )	Indoor Worker Mechanical (dpm/100 cm <sup>2</sup> )	Outdoor Worker Mechanical (dpm/100 cm <sup>2</sup> )	DOE 5400.5/ NRC 1.86 (dpm/100 cm <sup>2</sup> )	ANSI 13.12 (dpm/100 cm <sup>2</sup> )	Ratio ANSI/SPRG (outdoor worker)
Co-60	7.259	11.566	5.350	5,000	6,000	1,121
Cs-137+D	5.217	7.748	4.795	5,000	6,000	1,251
Ir-192	321.90	457.32	208.68	5,000	6,000	29
Po-210	0.533	0.591	0.264	-	600	2,271
Ra-226	0.009	0.012	0.005	100 <sup>a</sup>	600	110,314
Sr-90	1.114	1.512	0.739	1,000	6,000	8,116
Th-232	0.002	0.003	0.001	1,000	600	415,162
U-235	0.011	0.014	0.006	5,000	6,000	968,711
U-238	0.011	0.015	0.007	5,000	6,000	894,935

Notes:

- No standard
- +D And daughter products
- ANSI American National Standards Institute
- a This value applies only to NRC 1.86.

- cm<sup>2</sup> Square centimeter
- DOE U.S. Department of Energy
- dpm Disintegration per minute

**FIGURE 4  
SPRG SURFACE STANDARDS VS. EXISTING STANDARDS**



As shown above, the surface values generated by the SPRG calculator for typical beta gamma emitters are several orders of magnitude lower than surface values accepted by other federal agencies and ANSI. The alpha emitters (Po, Ra, Th, U) show even greater discrepancies.

### 6.3 SPRG CALCULATOR VALUES VS. EPA ROD VALUES

The SPRG calculator soil values were compared to ROD values previously approved by the EPA for the various CERCLA sites noted in Section 5.0. As Table 10 and Figure 5 show, the SPRG calculator values were much higher than the EPA-approved values for past remediations. The 2D-derived SPRG calculator soil values and the 3D-derived soil values were comparable to one another, so the 3D-values were used for comparison because they are slightly more restrictive. Additionally, SPRG calculator values were calculated for contamination at various depths. An RDD device is not expected to initially deposit contamination at depth. It is expected that subsequent precipitation may cause some of the contamination to move downward through the soil column, but this should be a relatively slow process compared to emergency remediation efforts. For these reasons, the cleanup guidelines were compared to the SPRG calculator values developed for contamination to a depth of 1 centimeter. The cleanup values in the RODs were developed for various receptors and exposure parameters but most commonly were presumed to be the residential scenario. The most conservative SPRG calculator values for all radionuclides of concern were for residential scenarios; therefore, the residential SPRG calculator values were used for comparison.

**TABLE 10**  
**ROD VALUES VS. SPRG CALCULATOR VALUES**

Radionuclide	ROD Values (pCi/g)	SPRG Values (pCi/g)	Ratio of SPRG to ROD Values
Co-60	1.4 to 3,356 <sup>a</sup>	248	177
Cs-137	1.4 to 67 <sup>b</sup>	361	258
Ir-192	-	18,240	-
Po-210	78	955,000,000	12,243,590
Ra-226	4.14 to 6.21	87.6	14
Sr-90	4.5 to 15	25,600	1706
Th-232	1.3 to 5	800,000	160,000
U-235	1 to 29	932	32.14
U-238	1.1 to 11	4,860	441

Notes:

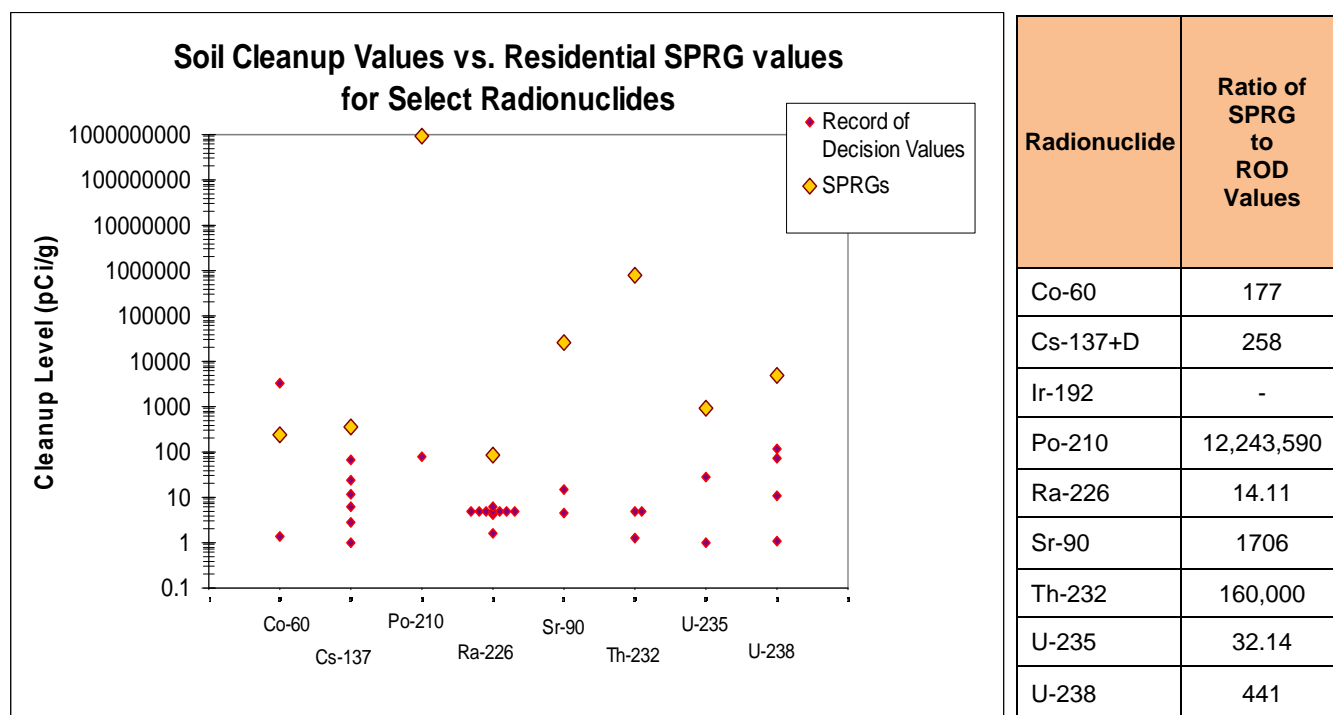
pCi/g Picocurie per gram

ROD Record of Decision

a The value of 1.4 pCi/g was used for comparison because the larger value was not for a residential scenario.

b The value of 1.4 pCi/g was used for comparison because the larger value was for a risk of 1E-04.

**FIGURE 5**  
**SPRG CALCULATOR SOIL VALUES VS. ROD VALUES**



As shown above, soil cleanup values derived by the SPRG calculator are significantly higher than values previously used at EPA Superfund sites as indicated in the ROD documents.

In all cases, the SPRG values were higher (less conservative) for soil concentrations to a depth of one centimeter. The ratio of the SPRG calculator soil cleanup values to previously approved EPA cleanup values spans seven orders of magnitude for radionuclides commonly associated with RDDs. This discrepancy does not indicate a simple bias and suggests there may be technical issues that warrant additional investigation.

## 6.4 SPRG CALCULATOR ISSUES

This section discusses seven issues related to the SPRG calculator and its practical application to RDD/IND long-term recovery operations.

### 6.4.1 Issue 1 – SPRG Values Not Internally Consistent

The SPRG calculator yielded inconsistent results when comparing the default download tables to the default calculator. Specifically, the results for the resident or mechanical resuspension for most of the 1,100+ radionuclides (including daughter products) in the database yielded significantly different results than the default SPRG calculator settings for the same radionuclides. The SPRG calculator and download values *should have yielded exactly the same results*. In approximately 1,000 cases, the results from the download tables differed from the calculator values. Of these 1,000 cases, approximately 900

differed by more than a factor of two. Therefore, 90 percent of the internal calculations disagreed, and approximately 80 percent of the internal calculations differed by more than 100 percent from one another. Roughly 9 percent of the values agreed completely. These differences were similar under several other scenarios. This suggests a lack of scientific rigor and quality assurance with these electronic tools.

#### **6.4.2 Issue 2 – SPRG Values Exceed SHEMP 38 Turnback Values**

Several of the SPRG calculator ground plane source values (see Table 8) exceed the EPA Safety, Health and Environmental Management Program Guideline 38 (SHEMP 38) turnback values. The SPRG calculator values for Po-210 (186,480,000 dpm/100 cm<sup>2</sup>), Th-232 (69,708 dpm/100 cm<sup>2</sup>), U-238 84,804 (dpm/100 cm<sup>2</sup>), and Ra-226 (4,240 dpm/100 cm<sup>2</sup>) all exceeded the SHEMP 38 turnback level of 2,000 dpm/100 cm<sup>2</sup> for alpha-emitting radionuclides<sup>12</sup>. In addition, the SPRG calculator value for Sr-90 (89,910 dpm/100 cm<sup>2</sup>) exceeds the SHEMP 38 turnback level of 10,000 dpm/100 cm<sup>2</sup> for beta-emitting radionuclides. This would potentially create a situation where emergency responders would require personal protective equipment in an area that could be released for public use. This suggests the SPRG tool was not evaluated against other existing EPA guidance documents, representing another example where quality assurance associated with this tool is questionable.

#### **6.4.3 Issue 3 – SPRG Values Not Detectable Using Field Instrumentation**

From the practical implementation standpoint, the surface SPRG calculator values would be undetectable using field instrumentation for nearly all of the radionuclides of interest (Ir-192 being a possible exception). Experience at EPA superfund sites has shown that PRG calculators have promulgated remediation goals that could not be distinguished from background values, could not be detected with handheld instrumentation and could not be detected by laboratory equipment.<sup>44</sup> Certainly, the alpha emitters, which would pose the greatest risk if inhaled or ingested (the hazard associated with resuspension), would be undetectable at the SPRG calculator levels using even the most sophisticated analytical laboratory equipment.

Attempts to detect and remediate contaminants to these levels would be time-consuming and expensive because of laboratory time and preparation requirements. For example, based on Currie's equation and the manufacturer's specifications<sup>45</sup> for the Model 43-90 alpha scintillation probe (background of 3 counts per minute and efficiency of 20 percent)<sup>45</sup>, it would take about 2,850 years of counting in addition to a background measurement of the same length of time in order to reach a minimum detectable activity (MDA) level equal to the surface SPRG calculator value for Th-232 of 0.001 dpm for a single sample. An RDD event could generate tens of thousands of sample points.

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<sup>12</sup> U.S. Environmental Protection Agency (EPA). 2006. Safety, Health and Environmental Management Program Guideline 38 (SHEMP 38), March.

Even under controlled conditions and using more sensitive instruments, a laboratory-based detector with ultra low background rate of 1 count per 1,000 minutes would require a count time of 833 days to theoretically achieve an MDA at the level of the SPRG value. It is typically desirable to have a stated MDA that is one tenth of the decision criterion. This would obviously extend the necessary count times. In addition, attempts to detect alpha emitters at the SPRG calculator levels would be severely hampered by the presence of water (from decontamination attempts or other sources).

This suggests the SPRG tool can not provide reasonable or practical clean-up guidance levels that can be implemented in field responses consistent with the OEM removal program. Further, it is questionable if it can even provide reasonable or practical estimates at the declared  $10^{-4}$  risk range.

#### **6.4.4 Issue 4 – Inconsistent Units of Measure**

The SPRG calculator yields results in units that are not consistent those used during field operations or by field equipment. For example, field instrumentation provides contamination results in units of dpm/100cm<sup>2</sup>. The SPRG calculator gives contamination results in units of pCi/cm<sup>2</sup>. The results would require additional conversions that are relatively simple to perform but not ideal for an OEM emergency response (that is, a very high stress environment with minimal time for review of conversions). The SPRG calculator should present all PRGs in units commensurate with field operations and equipment.

#### **6.4.5 Issue 5 – Risk-to-Dose Conversions**

The Department of Homeland Security guidelines for an RDD or IND incident provide Protective Action Guidelines (PAG) in units of dose (for example, 2 rem per year for the first year and 0.5 rem per year thereafter for re-occupancy). The SPRG calculator uses slope factors to report results as excess cancer risks. Users would be required to convert SPRG calculator excess cancer risk results to dose. These conversions are complex and subject to many caveats.<sup>46</sup> Analogous EPA calculators are being developed to calculate dose-based PRGs, but they are not functional at this date. It is unknown whether the SPRG calculator analog, Dose Compliance Concentrations for Radionuclides in Outdoor Surfaces (SDCC), has rectified the issues of download values differing from calculated values.

#### **6.4.6 Issue 6 – Scientific Review Uncertain**

Due to the quality assurance concerns with the differences between the calculated and downloaded SPRG values (Issue 1) and the conflict between the SPRG and the EPA SHEMP turn-back guidance (Issue 2), it was deemed prudent to verify the peer review process for the SPRG calculator. A literature search found the distribution memorandum for the SPRG calculator dated January 16, 2009 (OSWER 9355.5-26) This memorandum from James E. Woolford, Director of the Office of Superfund Remediation and Technology Innovation, indicates that the SPRG Electronic Calculator have undergone

internal peer review in 2007 and external peer review in 2008<sup>3</sup>. The memo also indicates that comments were received, addressed and the calculator was revised accordingly.

A review of the “Final Information Quality Bulletin for Peer Review” published in December 2004 by the Office of Management and Budget suggests that the SPRG calculator would be considered either “influential scientific information” or “highly influential scientific information.”<sup>47</sup> This bulletin requires Federal agencies to conduct peer reviews of “influential scientific information” prior to dissemination. OMB states “it also establishes a transparent process for public disclosure of peer review planning, including a web-accessible description of the peer review plan that the agency has developed for each of its forthcoming influential scientific disseminations.” The bulletin also indicates that a “more rigorous peer review is necessary for information that is based on novel methods or presents complex challenges for interpretation. Furthermore, the need for rigorous peer review is greater when the information contains precedent-setting methods or models, presents conclusions that are likely to change prevailing practices, or is likely to affect policy decisions that have a significant impact.”

The bulletin further states “in general, an agency conducting a peer review of a highly influential scientific assessment must ensure that the peer review process is transparent by making available to the public the written charge to the peer reviewers, the peer reviewers’ names, the peer reviewers’ report(s), and the agency’s response to the peer reviewers’ report(s). The agency selecting peer reviewers must ensure that the reviewers possess the necessary expertise. In addition, the agency must address reviewers’ potential conflicts of interest (including those stemming from ties to regulated businesses and other stakeholders) and independence from the agency.”

Attempts were made to find the internal review document, the external review document or information relative to the reviewers and their qualifications through the US EPA Science Inventory Peer Review Agenda pages. Neither the influential scientific assessments nor the highly influential scientific assessments pages contained information on the review of the SPRG calculator

#### **6.4.7 Issue 7 – Undefined Protocol for Combination of PRGs**

The SPRG and BPRG calculators do not contain specific instructions on how to combine the effects of different pathways. For instance, dust on outside surfaces can be resuspended both by wind and mechanical forces. The calculator will yield a guideline value for each method. However, on a contaminated roadway, both forces will be in effect. It is unclear if the user should combine the two values somehow or use the more restrictive of the two values. Since resuspension by one mechanism will reduce the available inventory for the other mechanism to resuspend contamination, this is a nontrivial calculation. The user’s guide to the calculators does not address this situation.

## 7.0 BPRG CALCULATOR EVALUATION

In addition to the SPRG calculator for outdoor surfaces, EPA developed a BPRG calculator for contaminated building walls and roofs as well as resuspension from these surfaces. The following sections compare the BPRG calculator values to the values in the BPRG website download tables (Section 7.1), the BPRG calculator surface values to existing standards (Section 7.2), and the BPRG calculator values to EPA-approved ROD values (Section 7.3).

For building release scenarios, there are two receptors: a [resident and an indoor worker](#). Again, the calculator model assumes that each receptor would have slightly different exposure parameters and thus slightly different remediation guidelines based on differences in occupancy and function. For all of the radionuclides of concern, the resident scenario default values are more restrictive and are considered below for comparison purposes.

### 7.1 BPRG CALCULATOR VS. WEBSITE DOWNLOAD VALUES

Unlike the SPRG calculator, the BPRG calculator values agreed with the BPRG download values for all of the radionuclides of concern. However, the BPRG values still present operational problems. Ambient air concentrations cannot be directly measured to the level required for most of the isotopes of concern. Air sampling followed by wet chemistry analysis would be required for most radionuclides. However, in the field, air concentrations change rapidly and dramatically and thus would make an unlikely parameter for building release. In addition, the surface BPRG values are much lower than the ANSI standards, typically by three orders of magnitude. Although the values are not as dramatically untenable as the SPRG calculator mechanical resuspension values, they are still unusually challenging to achieve.

### 7.2 BPRG CALCULATOR SURFACE VALUES VS. EXISTING STANDARDS

As is the case for the SPRG calculator, the BPRG calculator presents different PRGs based on the exposure pathway. Briefly, the exposure pathways include exposure to resuspended radionuclides in dust on indoor surfaces, direct exposure to interior dust, exposure to dust on roofs and exterior walls, and exposure to contaminated soil around the building. Two receptors are considered, a resident and an indoor worker. Each receptor has slightly different exposure parameters. In general, the BPRG calculator values for the residential scenario were lower (more restrictive) than the indoor worker and are used for further comparisons.

The BPRG calculator values were compared to the decontamination guideline values presented in NRC Reg. Guide 1.86, ANSI 13.12, and DOE Order 5400.5 as shown in Table 11. As previously stated, the ANSI standard is a consensus standard of U.S. experts and uses 1 millirem (mrem) as the basis for its decision. The DOE and NRC values primarily were derived based on equipment capability but are very consistent with the ANSI standard and were used as cleanup criteria by the Army Corp Of Engineers at the Linde site (see Table 1).

**TABLE 11**

**BPRG CALCULATOR VALUES VS. EXISTING STANDARDS  
RESIDENT RECEPTOR**

Radionuclide	BPRG Value		Ratio ANSI/ BPRG (dust)	BPRG Soil Volume Values (pCi/g)	ROD Cleanup Values (pCi/g)	Ratio BPRG/ROD Values (soil)
	Settled Dust (dpm/100 cm <sup>2</sup> )	3D Ground Plane (dpm/ 100 cm <sup>2</sup> )				
Co-60	7.61	11.7	788	81.3	1.4 to 3,356 <sup>a</sup>	58
Cs-137+D	4.20	16.8	1,429	119	1.4 to 67 <sup>b</sup>	85
Ir-192	468	639	13	4510	-	
Po-210	11.3	44,400,000	53	312,000,000	78	4,000,000
Ra-226	0.226	1040	2,655	7380		
Ra-226+D	0.216	3.55	2,778	25	4.14 to 6.21 <sup>c</sup>	5
Sr-90	2.51	22,000	2,390	357,000		
Sr-90+D	1.59	269	3,774	5260	4.5 to 15	361
Th-232	0.71	9240	845	154,000	1.3 to 5	30,800
U-235	1.03	36.2	5,825	258	1 to 29	8.9
U-238	1.15	11900	5,217	596,000		
U-238+D	0.777	116	7,722	1150	1.1 to 11	105

Notes:

- No standard

+D And daughter products

ANSI American National Standards Institute

cm<sup>2</sup> Square centimeter

a The value of 1.4 pCi/g was used for comparison because the larger value was not for a residential scenario.

b The value of 1.4 pCi/g was used for comparison because the larger value was for a risk of 1E-04.

c The average value of 5.0 pCi/g was used for comparison.

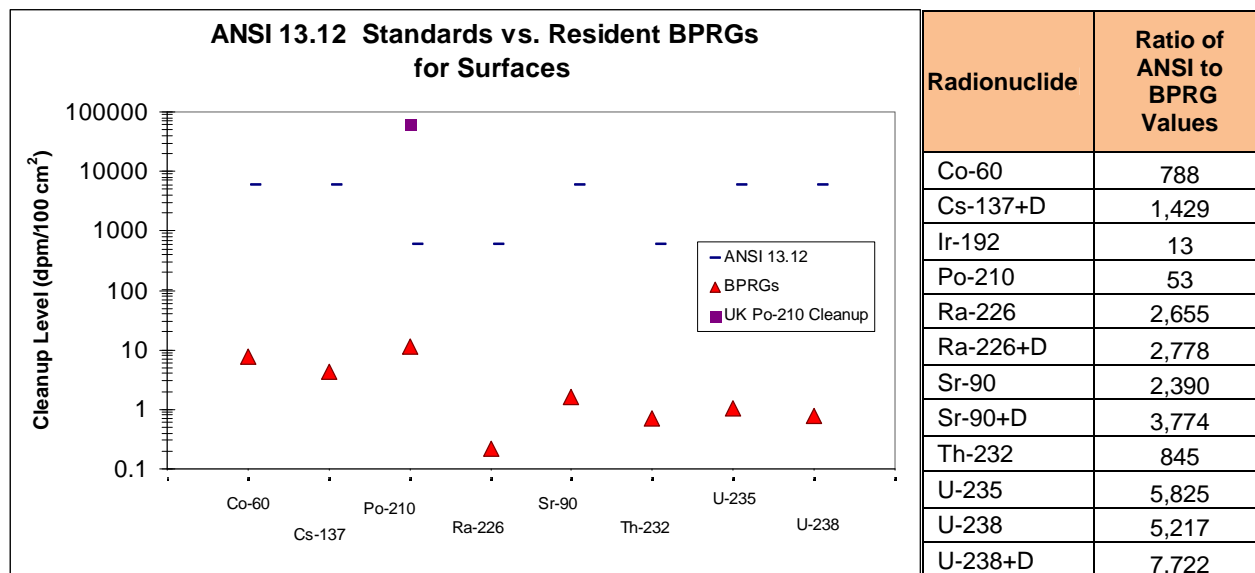
dpm Disintegration per minute

pCi/g Picocurie per gram

ROD Record of Decision

The BPRG calculator indoor worker settled dust values were compared to the ANSI 13.12 standard for surface contamination. As Figure 6 shows, the BPRG calculator values generally were about three orders of magnitude lower than the ANSI standards.

**FIGURE 6**  
**BPRG CALCULATOR VALUES VS. ANSI VALUES**



The notable exceptions were for the BPRG calculator values for Ir-192 and Ra-226, which were lower than the ANSI standards by factors of 13 and 53, respectively. In no case did the BPRG calculator value exceed the ANSI standard.

The ability to measure surface contamination parameters at the BPRG calculator levels would be technologically challenging. Most default BPRG calculator values are in the range of a few dpm/100 cm<sup>2</sup>, which is below typically attainable detection limits for survey equipment. The volumetric soil contamination values, on the other hand, generally are detectable using typical instruments, but such instruments are not likely to be used because contamination at depth is not anticipated. For this evaluation, the BPRG calculator values are orders of magnitude larger (less restrictive) than current cleanup values. BPRG Values for four of the radionuclides (Po-210 at 312,000,000 pCi/g, Sr-90 at 357,000 pCi/g, Th-232 at 154,000 pCi/g and U-238 at 596,000 pCi/g) appear inordinately high.

In addition to the technical challenges associated with attempts to quantify contamination at the BPRG calculator levels, current (and previous) standards and cleanup values for surface contamination would indicate that the BPRG values represent excess cancer incidence risk in the 10<sup>-9</sup> range rather than the 10<sup>-6</sup> range. As with the SPRG values, this is based on an ANSI standard calculated dose of 1 mrem per year being roughly equivalent to an excess cancer incidence of approximately one in one million (i.e. 10<sup>-6</sup> risk level). This demonstrates how assumptions built into the calculators influence the results. For long-term recovery operations following an RDD/IND attack those assumptions may result in a clean-up goals varying by at least three orders of magnitude.

Finally, the [UK clean-up criterion for Po-210](#) (60,000 dpm / 100 cm<sup>2</sup>) was successfully implemented at more than 40 contaminated locations throughout the city of London in the

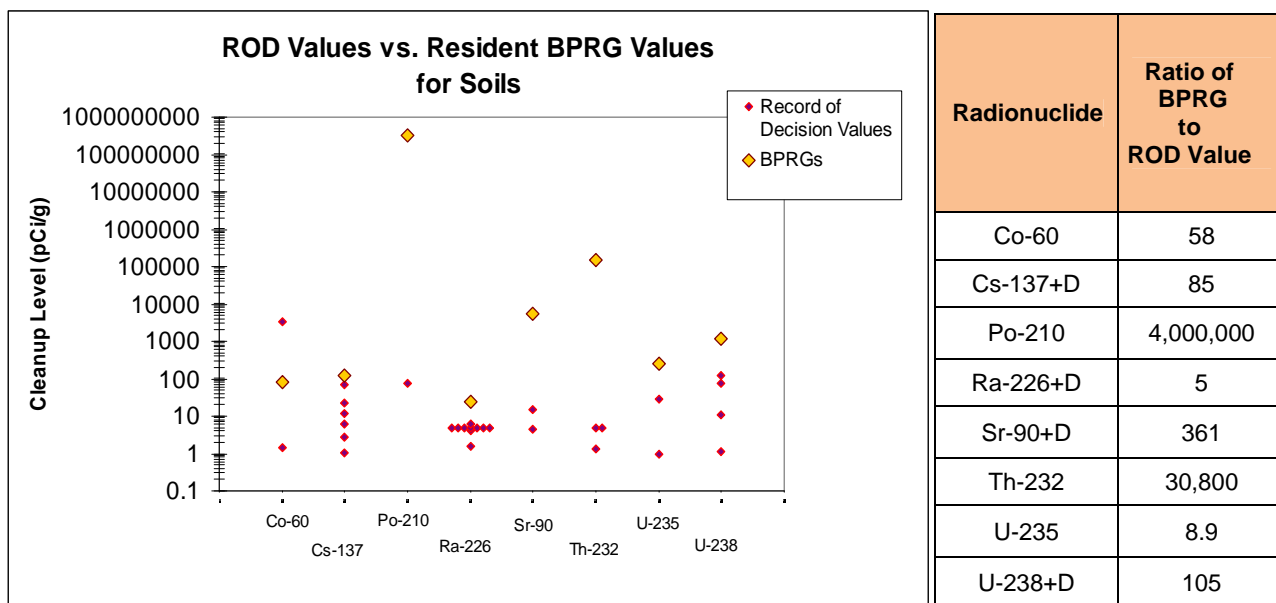
aftermath of the Litvinenko response. This incident was essentially an RDD scenario affecting a major metropolitan city during the height of the holiday shopping season. The incident also triggered an international response gaining the world's attention. Many factors (e.g., economic impact on the city during the height of a seasonal shopping period, tourism, international travelers, social acceptance, and health risks) were addressed in deriving this value which is more than 1,000 times the BPRG value, yet still protective to human health and the environment according to the UK Health Protection Agency. The balanced approach (radiation risk paradigm) had public support and resulted in a recovery effort lasting about six months. If that scenario occurred in the United States, it's unclear if the same success could be achieved, especially if special interest groups argue that the agency was raising the BPRG value by more than 1,000 times. The communication difficulties could result in severe political pressure, resulting in a much lower clean-up level than necessary, costing more money and time without a statistical ability to prove any net benefit or additional protection to human health or the environment. This is a real concern noted by the NCRP when only a specific segment of the stakeholder community is involved in the decision making process.<sup>8</sup> This real-world example demonstrates the political, economic, and societal benefits of using the radiation paradigm as compared to the chemical risk paradigm for RDD/IND long-term clean-up scenarios.

### 7.3 BPRG CALCULATOR SOIL VALUES VS. EPA ROD VALUES

The BPRG calculator 3D exposure model values (to a 1 centimeter soil depth) were compared to the maximum previous cleanup values found in the EPA-approved RODs summarized in Table 1. As Figure 7 shows, in general, the 3D exposure model BPRG calculator values agreed better with previous cleanup values than the similar comparison for the settled dust exposure values.

FIGURE 7

BPRG CALCULATOR SOIL VALUES VS. ROD VALUES



All of the BPRG calculator values were higher (less restrictive) than the ROD cleanup values. In general, the BPRG values differed were approximately two orders of magnitude higher. Two exceptions were for Po-210 and Th-232. The BPRG values for these two radionuclides were higher (less restrictive) by factors of approximately 4,000,000 and 30,000 times, respectively. It is not clear why these values differed so greatly from the ROD values, although the Th-232 BPRG value did not account for daughter product ingrowth, which would account for some variation.

## **8.0 CONCLUSION**

**The use of the SPRG and BPRG calculators for OEM Operations following an RDD or IND long-term recovery scenario is not recommended.** Neither calculator appears to have been benchmarked against existing standards, and the SPRG calculator has obvious and serious quality assurance issues. Based on the standards chosen for comparison in this evaluation, the SPRG and BPRG calculator values for soil are so much higher than previously used by EPA that it is uncertain whether they would be protective of human health and safety. For example, the calculators provide cleanup levels in soil that exceed the SHEMP turnback levels. Conversely, these calculators also provide extraordinarily low surface clean up levels - well below what can be detected or what can be distinguished from background levels. Both calculators report values in units that are not used by field responders. Finally, it does not appear that a peer review process was commensurate with that required for “highly influential scientific assessments” as documented in OMB requirements.

## **9.0 RECOMMENDATIONS**

In order for the PRG electronic calculators to become a viable tool for OEM operations, the following recommendations should be addressed:

### **9.1. STRENGTHEN PEER REVIEW PROCESS**

Conduct and document internal and external peer reviews that meet the requirements for “highly influential scientific assessments” as outlined in the OMB memorandum. Coordinate this activity with OEM and ORIA.

### **9.2 ACCOUNT FOR NATURAL BACKGROUND CONCENTRATIONS**

Screen the PRG results against natural background concentrations throughout the United States. If a calculated result falls below a pre-defined background concentration, then have the result reflect that by reporting “Below Background Concentrations.” Addressing this limitation in the FAQ section of the PRGs documentation is not acceptable.

### **9.2 ACCOUNT FOR MINIMUM DETECTABLE ACTIVITIES**

Screen the PRG results against a standardized list of laboratory and appropriate field instrumentation detection limits to ensure PRG values are detectable using current protocols and equipment. If a calculated result falls below a pre-defined detection limit, then have the result reflect that by reporting “Below Laboratory or Field Measurement Capability.” Addressing this limitation in the FAQ section of the PRGs documentation is not acceptable.

### **9.3. USE FIELD UNITS**

Update the models to yield results in units consistent with those of field and laboratory equipment. For example, pCi/cm<sup>2</sup> should be reported in dpm/100 cm<sup>2</sup> to eliminate the potential conversion errors during a response. Addressing this limitation in the FAQ section of the PRGs documentation is not acceptable.

### **9.4. RESOLVE CONFLICT WITH SHEMP MANUAL**

Reconcile the PRG results with the guidelines presented in the SHEMP 38 Guidance document. If the PRG results are higher than the SHEMP turnback levels, then the result should reflect “Above EPA Turn Back Levels” or the agency should reconsider the turnback levels if proven to be too conservative for emergency response applications.

### **9.5 RESOLVE DISPARITY BETWEEN SPRG CALCULATOR AND SPRG DOWNLOAD RESULTS**

Determine the appropriate method to correct the disparity between the SPRG calculator and the SPRG download results. Validate and verify these corrections and repeat the same process for the BPRG calculator, as required.

### **9.6 BENCHMARK THE TOOLS AGAINST OTHER ACCEPTABLE MODELS**

Strengthen the review process using recognized experts which includes benchmarking the results against recognized protocols and software (e.g., RESRAD models).

All of these recommendations are intended to strengthen the quality assurance issues and add value to the tools for OEM applications.

## REFERENCES

- <sup>1</sup> OSWER No. 9200.4-18, Establishment of Cleanup Levels for CERCLA Sites with Radioactive Contamination. Reference obtained from <http://www.epa.gov/superfund/health/contaminants/radiation/pdfs/rad.pdf> accessed on December 10, 2009.
- <sup>2</sup> EPA Preliminary Remediation Goals Frequently Asked Questions website: <http://epa-prgs.ornl.gov/radionuclides/faq.shtml>. Accessed on December 11, 2009.
- <sup>3</sup> Memorandum. Distribution of Superfund Preliminary Remediation Goals for Radionuclides in Outdoor Surfaces (SPRG) Electron' Calculator. From James E. Woolford, Director Office of Superfund Remediation and Technology Innovation to Superfund National Policy Managers, Regions 1-10. January 16, 2009. OSWER 9355.5-26. [http://www.epa.gov/oerrpage/superfund/health/contaminants/radiation/pdfs/memo\\_sprg\\_elec\\_calc.pdf](http://www.epa.gov/oerrpage/superfund/health/contaminants/radiation/pdfs/memo_sprg_elec_calc.pdf) accessed on December 11, 2009.
- <sup>4</sup> Planning Guidance for Protection and Recovery Following Radiological Dispersal Device (RDD) and Improvised Nuclear Device (IND) Incidents. 73 FR 45029 (August 1, 2008).
- <sup>5</sup> ICRP. International Commission on Radiological Protection. Publication 101. Assessing Dose of the Representative Person for the Purpose of Radiation Protection of the Public and The Optimisation of Radiological Protection: Broadening the Process. November 2006.
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